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AN EVALUATION OF SPRUCE ROOT ROT IN PETERSON GROVE, TEASDALE RANGER DISTRICT, DIXIE NATIONAL FOREST

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INTRODUCTION

Mortality and windthrow of Engelmann spruce and blue spruce in Peterson Grove, southwest of Teasdale, Utah, was first noted by District personnel in 1978. Forest Pest Management (FPM) pathologists first visited the area during the field season of 1978 to collect decay samples and evaluate the extent of damage. They found that visibly affected spruce was not homogenously distributed over the area and recommended that the area be intensively surveyed. The District received FPM funds to conduct a ground survey in 1980. The following report summarizes the results of this survey and observations of FPM Pathologists Jim Hoffman, Greg Filip (R-6, FPM), Ralph Williams, and Borys Tkacz, following visits to Peterson Grove in 1978, 1979, 1980, and 1982.

SITE DESCRIPTION

Peterson Grove is located on the Aquarius Plateau in southern Utah (T. 31 S., R. 3 E., Sec. 7,18 and T. 31 S., R. 2 E., Sec. 12,13) (Figure 1). The surveyed stand is on a gently sloping north aspect at an elevation of 9,500 to 9,900 feet. A soil survey of Peterson Grove [1/] classified the soils over most of the area as members of the loamy, skeletal, mixed family of Mollic Cryoboralfs. These deep, well-drained soils weathered from basaltic andesite. The surface layer is dark reddish-brown, cobbly, silt loam, about 6 inches thick, and the subsoil is dark reddish-brown, extremely cobbly, silty clay loam extending to depths of over 40 inches. Available water-holding capacity is 4 to 5 inches for a 40-inch profile. The soil reaction ranges from pH 6.8 to 8.0. On the north side of Peterson Grove, the soils belong to the fine, mixed family of Argic Cryoborolls which are deep, well-drained soils with a surface layer of dark-brown, cobbly, heavy loam, about 5 inches thick. The subsoil is a dark-

1/ Bayer, J. T. 1978. Peterson Grove Timber Sale-Soil Survey. USDA Forest Service. Dixie NF unpublished report.

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brown to reddish-brown, gravelly, heavy clay loam which extends deeper than 40 inches. The soil reaction ranges from 6.2 to 6.4, and the available water-holding capacity for a 40-inch profile is 6 to 7 inches. Both of these soils have a cold temperature regime with moderate infiltration rates and slow permeability. Timber productivity and reforestation potential are typically moderate.

An infestation of spruce beetle (Dendroctonus rufipennis (Kirby)), which lasted from 1916 to 1928, killed all but the youngest spruce trees on 115,000 acres of the Aquarius Plateau (Mielke 1950). Smaller dead trees were removed for mine props, starting about 1935, and salvage logging for saw logs began in 1944. By 1948, most of the dead spruce on the plateau were cut, and salvage operations moved to the Boulder Top. Most of the current overstory trees in Peterson Grove are spruce that were either too small to be attacked by the beetle or became established after the outbreak. Douglas-fir and subalpine fir occur less frequently than spruce. Aspen is found in many openings throughout the grove. The spruce and aspen stands are bordered by open park areas occupied by silver sage and sheep fescue.

METHODS

A ground survey to determine extent and distribution of root rots was conducted by Teasdale Ranger District personnel during July and August 1980. Field crews were trained by FPM pathologists to recognize signs and symptoms of spruce root rots. Variable radius plots (BAF 40) were systematically located on a 400-foot grid over the 1,300-acre area (Figure 2). The following data were collected for all conifers greater than or equal to 5-inches diameter at breast height (DBH): species, DBH in inches, total height in feet, and condition (live healthy, live infected, or dead). All trees within the plot were bored at the base with an increment borer to determine presence of internal stain or decay. Data collected were used to calculate mean basal area, number of trees, and volume per acre by tree species, DBH class, and condition. Fixed area plots (.01 acre) were established at each plot center to determine numbers of seedlings and saplings.

The surveyed area was subdivided into five sections by Borys Tkacz and Robert Fillmore, Forestry Technician, Teasdale Ranger District, based on apparent differences in overstory species composition (Figure 2) to determine if disease severity is related to stand composition.

Samples of decayed wood were collected by FPM pathologists on four separate occasions to determine the causal agent. Small wood chips were placed on sterile nutrient media in petri plates. The plates were incubated to allow growth of microorganisms.

RESULTS

1. Species Distribution - The pooled data for all sections indicate that 79 percent of the stems per acre (S/A) were Engelmann spruce, representing 72 percent of the board-foot volume per acre (BF/A) (Table 1). The remaining 21 percent of the S/A and 28 percent of the BF/A were blue spruce. The delineated sections (Figure 1) differed considerably in the relative proportions of blue and Engelmann spruce. Section A contained greater amounts of blue spruce than any other section. Section C contained primarily Engelmann spruce (Table 1). Other species occasionally encountered were: Douglas-fir, subalpine fir, and ponderosa pine. Although aspen occurs commonly throughout the area, no data were collected for this species.

Both Engelmann spruce and blue spruce were regenerating in the area. Although regeneration was abundant in some areas, the section averages indicate low levels throughout the entire stand (Table 2). Engelmann spruce regeneration was more successful than blue spruce throughout the entire area.

2. Causal Agent - Culturing wood chips from decay samples yielded wood-decaying fungi. However, since the cultural characteristics were variable, and fruiting bodies were not found during the first three visits, positive identification was hampered. During the visit to the area in October 1982, fruiting bodies of Inonotus tomentosus (Fr.) Gilbertson [2/] were found on or near several infected Engelmann spruce saplings, as well as near the base of an infected mature tree. Fruiting bodies of this fungus are annual and are usually produced during the fall after periods of high rainfall. Because of the dry climate of southern Utah, they are rare or absent most years. They are small (approximately 1 to 4-inch diameter), firm, yellow-brown with a pale buff pore layer underneath. They usually have a central stalk up to 1.5 inches tall and can be found on the ground surrounding infected spruce (Gilbertson 1976). Laboratory analysis and culturing from fruiting bodies and wood samples from saplings and mature trees collected throughout the area confirmed the initial field identification of the causal organism as I. tomentosus. Collections of decay samples will continue to determine if other fungi are also involved in the area.

3. Disease Distribution - Spruce root rot was found to be widespread throughout the surveyed area (Figure 2). A total of 201 plots contained trees exhibiting root rot; an additional 30 plots contained all healthy trees but were adjacent to diseased areas, and 133 plots were located in healthy portions of the stand. Sections A and B contained the highest proportions of diseased plots; whereas, sections C and D had the lowest proportions of diseased plots.

Blue and Engelmann spruce of all size classes were infected with or killed by the root rot (Table 3). The survey results (all sections pooled) indicate that both species are susceptible to the disease. Nine percent of the stems per acre (S/A), representing 8 percent of the board foot volume per acre (BF/A), were dead; 29 percent of the S/A, representing 38 percent of the BF/A, were alive but infected; and 62 percent of the S/A, representing 64 percent of the BF/A, were alive and apparently healthy (Table 1). Root excavation would probably have uncovered even more infected trees. The five delineated sections differed somewhat in species composition and relative proportions of trees infected and killed by the disease. Sections C and D contained high proportions of Engelmann spruce with correspondingly lower levels of overall infection and mortality than the other sections; whereas, sections A and B had higher proportions of blue spruce than the other sections, with correspondingly higher disease levels. However, the combined data for all sections did not indicate any higher incidence of the disease in blue than in Engelmann spruce (Tables 1 and 3).

DISCUSSION

1. Biology of Pest - Inonotus tomentosus attacks many conifers throughout temperate-zone forests of the northern hemisphere (Whitney 1977). It causes root rot of white spruce in Saskatchewan (Whitney 1962); white pine, Engelmann

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[2/] Fruiting bodies were identified by Dr. R. L. Gilbertson of the University of Arizona. Inonotus tomentosus is synonymous with Polyporus tomentosus (Fr.).

spruce, Douglas-fir, western hemlock, and western larch in northern Idaho (Hubert 1929, Hobbs and Partridge 1979); and white spruce, black spruce, Jack pine, and balsam fir in Minnesota and Wisconsin (Christensen 1940, Myren and Patton 1971).

Most of the existing information on the biology and epidemiology of Inonotus tomentosus is based on research conducted in planted and natural stands of spruce in Canada (Whitney 1962, 1977) and the northern United States (Myren and Patton 1971). Disease centers are initiated either by basidiospores, which can infect wounded roots, or by mycelium from previously diseased roots. The fungus may survive in buried roots for at least 20 years following the death of the host (Whitney 1977). Poor planting practices result in dead or deformed roots and have led to infection by I. tomentosus (Ouellette et al. 1971). The main spread within a stand is by root contacts between healthy and diseased roots. Following initial infection, the fungus spreads throughout the major roots and butt of a tree. Since I. tomentosus grows as slow as 1 to 10 cm. per year in spruce wood, about 15 to 20 years may elapse between initial infection and death by girdling (Whitney 1962). The fungus decays wood, initially causing a dark reddish-brown stain in which white pockets develop. As the pockets develop, the wood becomes extremely porous, soft, and weak (Whitney 1977). Decay seldom extends more than several feet into the bole. Gradual killing of roots by I. tomentosus results in appreciable reductions in height and diameter growth long before death of the host tree. Crown symptoms, including reduced internode length, short needles, abnormal curling of branches, and chlorotic foliage, may not appear until 40 percent of the roots are dead (Whitney 1962). Decay of main supporting lateral roots greatly reduces windfirmness and may lead to windthrow of green trees. Tree-to-tree spread of the disease and windthrow of infected trees results in expanding openings in the stand. Susceptible regeneration in these openings becomes infected when roots contact buried residual roots of previously killed trees (Whitney 1972). Therefore, harvesting infected stands and regenerating with susceptible species perpetuates the disease.

The results of our laboratory culturing and ground survey indicate that Engelmann and blue spruce are susceptible to attack and killing by I. tomentosus. Ponderosa pine, lodgepole pine, and Douglas-fir are also susceptible to infection (Whitney and Bohaychuk 1976). There are no reports of natural infection of hardwood species (Whitney 1977).

Many of the disease centers in Peterson Grove have been taken over by aspen. Aspen is resistant to infection by I. tomentosus. Deprived of suitable host material, the fungus gradually dies out of previously killed spruce roots in areas where aspen has occupied the site.

2. Damage - Attack by Inonotus tomentosus on tree roots may result in mortality, premature windfall, growth reduction, and butt cull (Whitney 1977). The present survey has quantified the amount of mortality and infection in trees larger than 5 inches DBH occurring in Peterson Grove. Similar levels of infection and mortality have been reported in other areas. Surveys in 70 to 111-year-old white and black spruce stands in Saskatchewan revealed volume losses averaging 28 percent due to root rot-caused mortality. Trees representing another 12 percent of the stand volume were infected with root rots (Whitney 1973).

The present survey of Peterson Grove has not attempted to quantify losses due to growth reduction or cull resulting from infection by I. tomentosus. The

high proportion of live infected trees indicates that these losses may be substantial. Lachance (1978) found that rotted trees grew 27 percent less wood than sound trees in a white spruce plantation in Quebec. Since I. tomentosus is usually a root and butt-rotting fungus, losses due to cull are lower than for heart rots of the main bole (Hinds 1977).

Spread of Inonotus tomentosus results in openings in the stand which are not capable of supporting susceptible species for extended periods of time. These "areas out of production" also constitute a considerable loss in stands where the prime commercial species are susceptible. Although much of Peterson Grove appears to be occupied by large, active disease centers, the present survey has not quantified this loss nor the rate of center expansion. Myren and Patton (1971) observed spread of I. tomentosus in white spruce plantations in Wisconsin over a 4 year period. They found that the total area occupied by 10 disease centers increased by 14.5 percent per year.

Canadian researchers have found that root rot caused by Inonotus tomentosus occurs in spruce on a variety of sites but is most damaging "where soils are very acidic (pH 4-5) and low in nutrients and moisture-holding capacity, and where rooting depth is restricted by shallow or compact soils" (Whitney 1977). The fungus is capable of growth at lower soil temperatures than common competitors (Whitney 1962). The soils in Peterson Grove are typical of those developing under cold temperature regimes. [3/] They are not as acidic as those reported by Whitney (1977) for infected stands in Canada.

Infection of the current stand trees in Peterson Grove by Inonotus tomentosus probably resulted from contact with infected roots of the previous stand residuals. Mielke (1950) reported that root rot fungi were causing windthrow of the spruce beetle-killed trees on the Aquarius Plateau and Boulder Top. He speculated that these trees may have been infected by the rots before they were killed by the beetle. Although Mielke did not attempt to identify the rots involved, Hinds and others (1965) found Inonotus tomentosus "generally distributed" in spruce beetle-killed trees in western Colorado. It is not known whether I. tomentosus can infect a beetle-killed tree following its death. If this were possible, such a buildup of the disease would lead to high losses in the succeeding stand.

MANAGEMENT CONSIDERATIONS

Root rot caused by Inonotus tomentosus can be called a "disease of the site," since the pathogen survives for extended periods of time in woody material and can infect susceptible regeneration on the site. Stand management recommendations in the literature are limited to the following: clear-cutting heavily infected stands, converting to hardwoods or less susceptible conifers, and utilizing proper planting techniques to avoid deformed roots (Whitney 1977). Cutting only symptomatic trees will salvage potential mortality but will not reduce spread of the disease to the remaining trees.

The following discussion of management considerations for Inonotus tomentosus-infected stands in Peterson Grove is based on a compilation of applicable management recommendations developed for stands infected by I. tomentosus and other similar diseases in other areas.

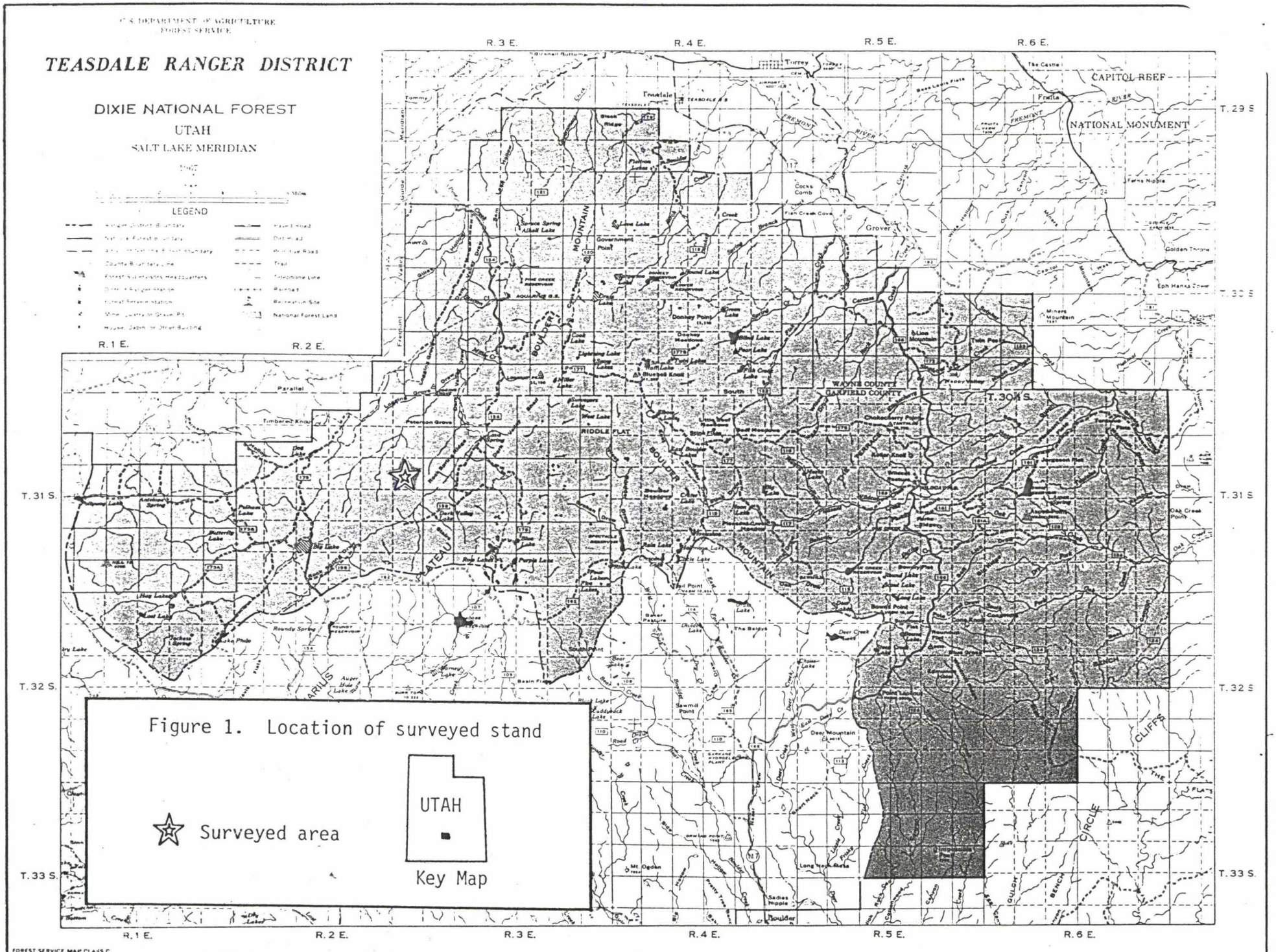
[3/] See Site Description.

1. Regeneration Cutting - This is perhaps the most critical phase of stand management in areas where the root disease is prevalent. Immediate regeneration of susceptible species on root disease-infected sites perpetuates and perhaps increases the disease in subsequent rotations (Tkacz and Hansen 1982, Whitney 1972). The incidence and pattern of infection in the harvested stand will determine the subsequent disease levels in the regenerating stand. Careful examination and mapping of infection centers is necessary to identify areas in need of special treatment. The disease may be found on trees 30-40 feet beyond the last visibly infected tree; therefore, a buffer zone of about 50 feet should be treated, along with the obvious infection center. If infection centers are to be immediately regenerated to susceptible species, remove all stumps and major roots in the infection center and within 50 feet of infected stumps. This may be accomplished by pushing out stumps with heavy machinery after the harvest or by pushing over whole trees during harvest operations. In areas where stump removal is not feasible, infection centers can be regenerated to immune species (i.e., hardwoods). Aspen can be grown in infection centers in Peterson Grove. After approximately 40 years, these centers can be regenerated to susceptible species. Observations in and around Peterson Grove, as well as laboratory pathogenicity tests by Whitney and Bohaychuk (1976), indicate that Douglas-fir is less susceptible to the disease than spruce. Immediate regeneration of infection centers by Douglas-fir may result in lower disease levels but probably will not rid the site of the disease. Douglas-fir is susceptible to the disease but is not normally killed by it. Infection centers can also be taken out of timber production and converted to grass or brush for approximately 40 years. Broadcast burning usually does not result in soil temperatures high enough to kill the fungus in deeply buried roots. Shelterwood or seed-tree cuttings should not be used in infected areas, since they result in immediate regeneration to susceptible species. Additionally, infected trees are not windfirm due to decayed root systems. Patch clearcutting or group-selection cutting can be effective if entire infection centers plus a 50-foot buffer are cut and treated as described above. Where the disease is widely distributed, stand clearcutting may be the best alternative. Infection centers should be marked prior to harvest and treated as described above.

2. Intermediate Cutting - Intermediate cuttings of infected stands will produce varied results, depending on amount and distribution of disease and intensity of cutting. Thinning in heavily infected stands may be followed by increased windthrow of crop trees. Although the rate of spread of the disease should not be accelerated, windthrow of infected trees may increase when the stand is opened. Infected trees probably will not release following thinning. Salvage or sanitation cuttings will be effective in salvaging existing and potential mortality. Since I. tomentosus decay is usually confined to the roots and butt of a tree, the remaining sound volume can be salvaged even after death or windthrow. If stands can be entered frequently (i.e., at 5-year intervals), salvage dead and visibly affected trees. If stand entries cannot be made at intervals of less than 10-15 years, harvest all visibly affected trees and all susceptible trees within 30 to 40 feet. These treatments will not stop or retard the spread of the disease but will salvage useable volume. Stand entries during wet periods may lead to soil compaction in portions of Peterson Grove. [4/]

4/ Bayer, op. cit.

Forest Pest Management is currently cooperating with Dixie National Forest personnel in setting up a demonstration of some of the above management techniques to reduce root disease-caused losses in Peterson Grove. Plots will also be established to determine the rate of spread of the disease and its effect on tree growth. This information will be useful in further refining management techniques to reduce losses in other affected stands.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TEASDALE RANGER DISTRICT
DIXIE NATIONAL FOREST
UTAH
SALT LAKE MERIDIAN
LEGEND
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R. 2 E.
R. 3 E.
R. 4 E.
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T. 29 S.
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CAPITOL REEF
NATIONAL MONUMENT
WAYNE COUNTY
GARFIELD COUNTY
Teasdale
Torrey
Grover
Fremont River
Boulder Mountain
Aquarius Plateau
Riddle Flat
Thousand Lake Mountain
Miners Mountain
Golden Throne
Eph Hanks Tower
Cockscomb
Fish Creek Cove
Deer Mountain
Sawmill Point
South Point
Mt. Ogden
Sadies Nipple
Long Horse Butte
Circle Cliffs
Gulch
Bench
Flat
Figure 1. Location of surveyed stand
Surveyed area
UTAH
Key Map
FOREST SERVICE MAP CL49 C

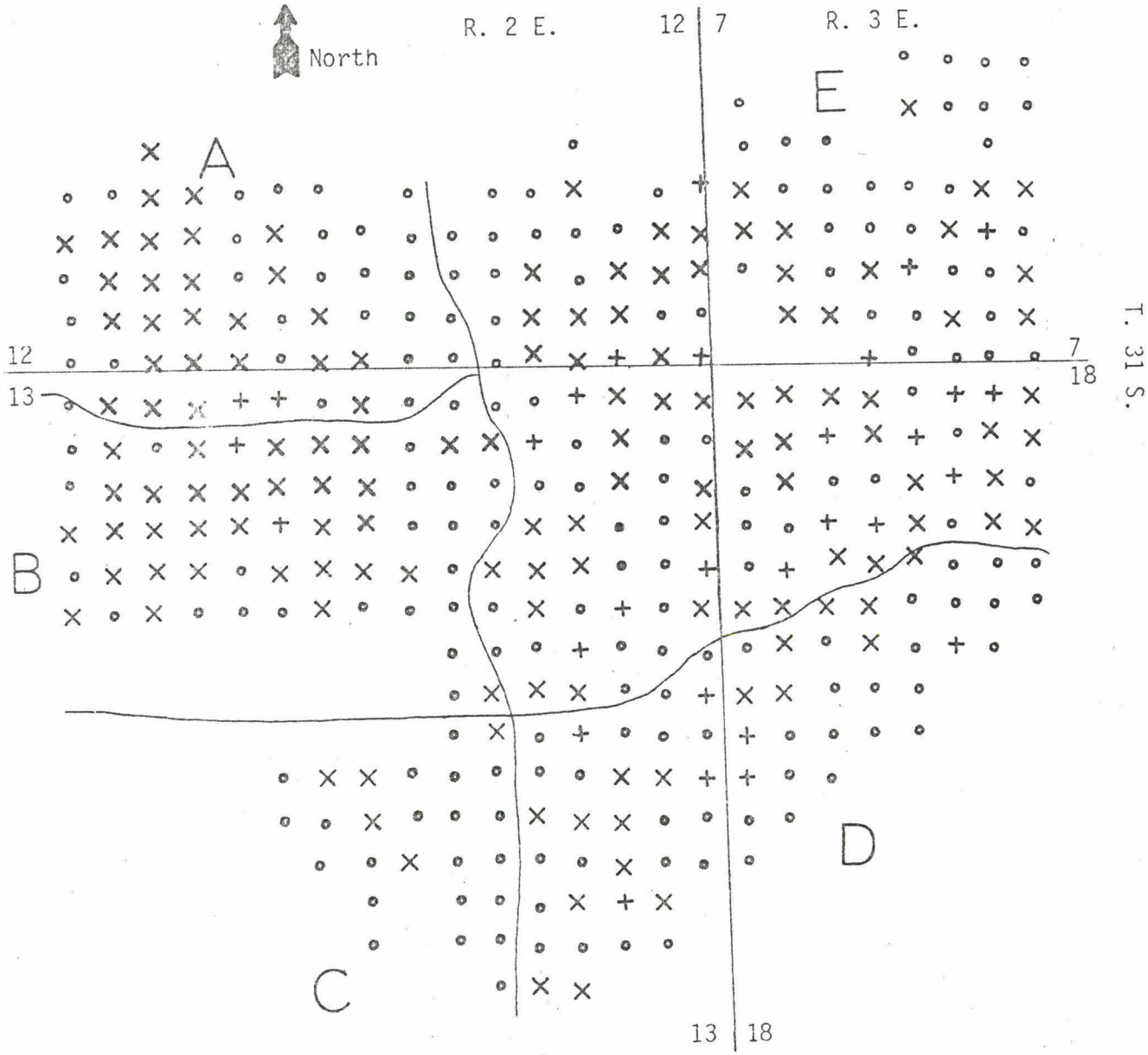

Figure 2. Location of variable radius plots in
Peterson Grove
Teasdale Ranger District
Dixie National Forest

Survey sections indicated by capitol letter.
° Healthy plot
× Root rot infected plot
\+ Healthy plot adjacent to infection center

Scale 1:18,500

of blue and Engelmann spruce by condition for the

	ENGELMANN SPRUCE						BOTH SPECIES							
	INFECTED		DEAD		TOTAL		LIVE		INFECTED		DEAD		TOTAL	
	BF/A	S/A	BF/A	S/A	BF/A	S/A	BF/A	S/A	BF/A	S/A	BF/A	S/A	BF/A	S/A
8	2013.0 (41)[a]	35.1 (34)[a]	349.6 (7)[a]	6.6 (7)[a]	4934.3 (100)[a] (62)[b]	102.5 (100)[a] (78)[b]	4843.2 (61)[a]	83.1 (63)[a]	2326.8 (29)[a]	37.3 (29)[a]	849.2 (11)[a]	10.4 (8)[a]	8022.2 (100)[a] (100)[b]	130.8 (100)[a] (100)[b]
9	1563.0 (34)	49.0 (43)	211.6 (5)	16.2 (14)	4610.2 (100) (66)	115.1 (100) (81)	4453.9 (63)	64.6 (45)	2118.2 (30)	59.8 (42)	450.1 (7)	17.8 (13)	7022.2 (100) (100)	142.2 (100) (100)
9	473.8 (6)	14.4 (11)	532.8 (7)	17.9 (13)	7771.5 (100) (91)	136.2 (100) (92)	7195.3 (85)	110.2 (75)	790.4 (9)	19.3 (13)	532.8 (6)	17.9 (12)	8518.5 (100) (100)	147.4 (100) (100)
6	1094.9 (29)	15.7 (26)	32.3 (1)	1.8 (3)	3803.2 (100) (78)	60.1 (100) (83)	3630.9 (74)	53.8 (74)	1094.9 (23)	15.7 (22)	162.9 (3)	2.8 (4)	4888.7 (100) (100)	72.3 (100) (100)
0	1267.8 (28)	17.6 (28)	394.5 (8)	6.4 (10)	4583.8 (100) (74)	64.0 (100) (74)	3684.8 (59)	53.3 (62)	1930.7 (31)	25.4 (29)	597.2 (10)	7.4 (9)	6212.7 (100) (100)	86.1 (100) (100)
6	1363.2 (29)	24.2 (30)	316.6 (7)	7.4 (9)	4728.0 (100) (72)	81.2 (100) (79)	4178.3 (64)	63.6 (62)	1816.1 (28)	30.0 (29)	539.1 (8)	8.9 (9)	6533.5 (100) (100)	102.5 (100) (100)

Table 2. Relative frequency (stems per acre) of regeneration by species and survey section for Peterson Grove.

SURVEY SECTION	BLUE SPRUCE		ENGELMANN SPRUCE		BOTH SPECIES	
	Seedlings	Saplings	Seedlings	Saplings	Seedlings	Saplings
	Stems per acre					
A	96 (48)[a]	41 (22)	104 (52)	149 (78)	200 (100)	190 (100)
B	51 (46)	22 (22)	60 (54)	80 (78)	111 (100)	102 (100)
C	0 (0)	4 (3)	192 (100)	131 (97)	192 (100)	135 (100)
D	25 (15)	14 (13)	137 (85)	92 (87)	162 (100)	106 (100)
E	70 (40)	37 (47)	107 (60)	41 (53)	177 (100)	78 (100)
Average	48 (29)	24 (20)	120 (71)	99 (80)	168 (100)	123 (100)

[a] percent of total for both species.

Table 3. Basal area per acre (BA/A), stems per acre (S/A), and board foot volume per acre (BF/A) of blue and Engelmann spruce by diameter classes.

		BLUE SPRUCE									ENGELMANN SPRUCE								
		LIVE			INFECTED			DEAD			LIVE			INFECTED			DEAD		
DBH (in.)	AVG. HT (ft.)	BA/A	S/A	BF/A	BA/A	S/A	BF/A	BA/A	S/A	BF/A	BA/A	S/A	BF/A	BA/A	S/A	BF/A	BA/A	S/A	BF/A
6	31	.56	2.9	2.8	0.11	0.6	0.6	0	0	0	2.15	10.9	10.6	0.90	4.6	4.5	0.34	1.7	1.7
8	37	1.13	3.2	49.7	0.79	2.3	34.8	0	0	0	3.28	9.4	144.2	1.47	4.2	64.6	0.45	1.3	19.9
10	41	1.13	2.1	73.0	0.23	0.4	14.6	0.11	0.2	7.3	4.86	8.9	314.1	3.39	6.2	219.1	1.47	2.7	95.0
12	47	1.36	1.7	113.8	0.68	0.9	56.9	0.34	0.4	28.4	6.33	8.1	531.1	2.94	3.7	246.6	0.68	0.9	56.9
14	51	1.36	1.3	130.7	0.68	0.6	65.3	0.23	0.2	21.8	6.21	5.8	598.8	3.05	2.9	294.0	0.45	0.4	43.6
16	56	1.13	0.8	123.7	0.56	0.4	61.9	0.45	0.3	49.5	3.73	2.7	408.3	2.03	1.5	222.7	0.23	0.2	24.7
18	59	1.58	0.9	186.0	0.34	0.2	39.9	0.23	0.1	26.6	3.39	1.9	398.6	1.13	0.6	132.9	0.11	0.1	13.3
20	61	1.36	0.6	166.9	0.34	0.2	41.7	0.23	0.1	27.8	2.26	1.0	278.1	0.56	0.3	69.5	0.11	0.1	13.9
22	60	0.45	0.2	57.9	0.34	0.1	43.4	0.23	0.1	28.9	1.24	0.5	159.1	0.11	0.0	14.5	0	0	0
24	66	0.23	0.1	31.8	0.45	0.1	63.6	0	0	0	0.34	0.1	47.7	0.11	0.0	15.9	0.34	0.1	47.7
26	64	0.11	0.0	15.4	0	0	0	0	0	0	0.34	0.1	46.2	0.23	0.1	30.8	0	0	0
28	63	0.45	0.1	60.6	0.23	0.1	30.3	0	0	0	0.56	0.1	75.8	0.23	0.1	30.3	0	0	0
30	74	0.23	0.1	35.6	0	0	0	0	0	0	0.23	0.1	35.6	0.11	0.0	17.8	0	0	0
32	67	0.45	0.1	64.4	0	0	0	0.23	0.0	32.2	0	0	0	0	0	0	0	0	0
34	--	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
36	74	0.11	0.0	17.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
38	--	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total All Classes		11.64	14.0	1130.1	4.75	5.8	452.9	2.03	1.5	222.5	34.92	49.6	3048.2	16.27	24.2	1363.2	4.18	7.4	316.6

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